NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Fleet DNA



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Project ID: VSS119

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Overview

Timeline

Project Start Date: FY 12

Project End Date: Goal to continue data collection and database development through FY 14

Percent Complete: ~40%

Barriers

- **Cost:** Reduce the significant costs associated with the evaluation of vehicle components and configurations by providing access to data reporting and analysis capabilities
- **Risk Aversion:** Address risk issues by providing easily accessible info. to potential consumers
- **Computation models, design and simulation:** Accurate modeling requires real world data for successful development and validation

Budget

Total Project Funding FY 13: $400k

- DOE Share: $400k
- Contractor Share: Partner cost share has been in-kind support (vehicle loans, technical support, data access and data supplied to NREL) and varies by individual partner

Funding Received in FY12: $400k

Partners

Variety of contributing partners from industry, government, universities, and other labs required for successful database development and deployment. Past and present partners include:

- NREL - Project lead
- ORNL - Data collection partner
- Preliminary partners include Calstart, SCAQMD, CARB, Zonar, NTEA/GTA
  - Additional fleet and OEM partners planned

Relevance

- **Fleet DNA serves as a data storage warehouse for medium and heavy-duty vehicle fleets**
  - Vehicle drive cycle data is collected and stored for analysis and modeling applications
    - Real world data source for model development and validation
    - Storage of the results of past/present/future data collection efforts improving analysis efficiency and sharing of data
    - Data source for drive cycle development and testing
- **Fleet DNA normalizes and processes raw data generating 250+ unique statistics over three separate time scales for reporting and analysis**
  - Normalization allows for comparisons based on varying input data
    - Multiple data sources and formats
  - Results used to generate reports which characterize vehicle operating behavior
    - Microtrip, trip, and day level analysis available
    - Dynamics, temporal, and energy/power statistics calculated
  - Fleet results can be viewed relative to one another across many different classifications
    - class, vocation, type, drivetrain, fuel
      - Additional in-depth analyses, expanded capabilities for reporting

Milestones

Month / Year	Milestone or Go/No-Go Decision	Description	Status
July 12	Milestone report to DOE	Draft report highlighting database status and data compiled	Completed
August 13	Milestone report to DOE	Draft report highlighting database and data compiled	Pending

Approach – Fleet DNA Development

Data Storage

- Establish Data storage location and behavior

Database Structure

- Define database structure, data types, and process flow

Data Selection and Collection

- Determine high priority data vocations
- Integrate existing databases and collected data

Data Reporting

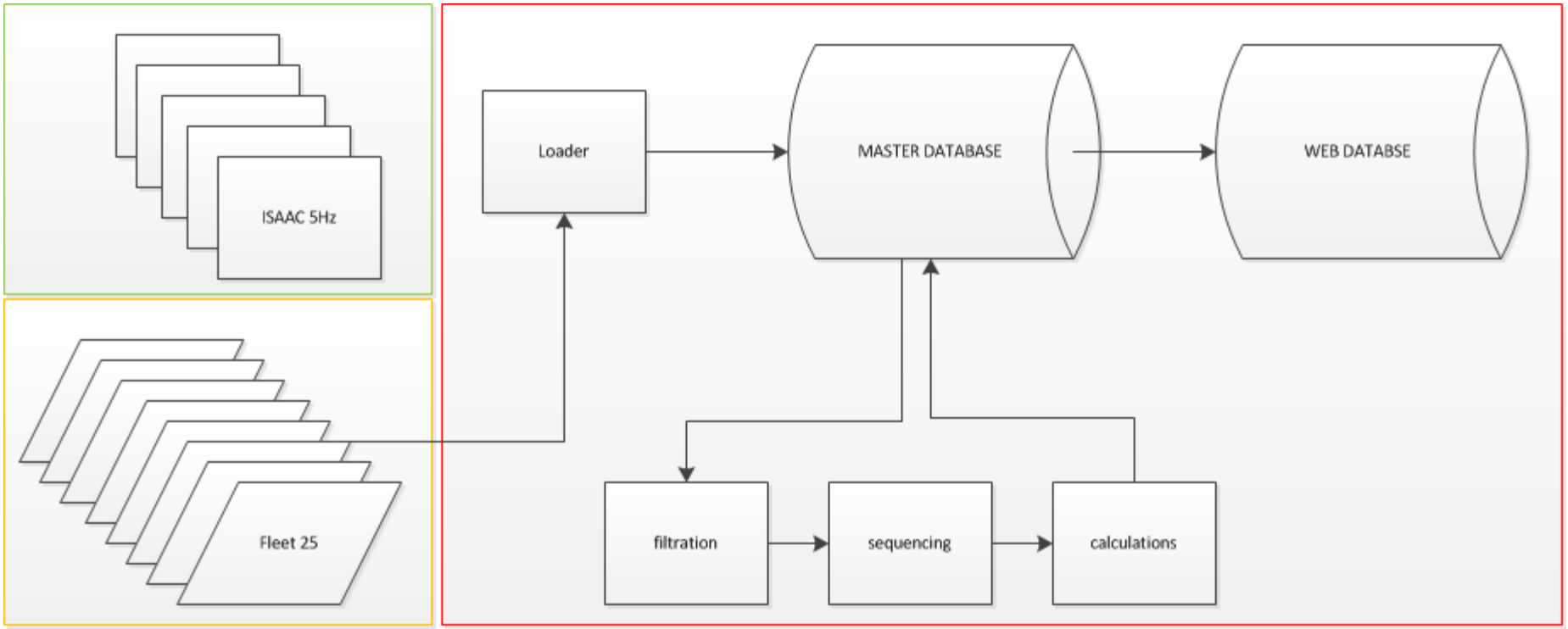
- Develop reporting capabilities
- Determine reporting format and prepare for deployment

Approach – Data Storage

- **Data transfer/upload**
  - Data uploaded directly from ongoing VT data collection activities or from data partners via secure FTP
- **Data protection**
  - Data stored on secure raw data handling server
  - Building badge access
  - On-site security force
  - Room key access
  - Limited to data center staff
- **Data backups**
  - Data mirrored on large storage array
  - Regular tape back-up
  - Fire/disaster protection for copies

NREL Data Center Storage Arrays

Approach – Database Structure



- **Database Loaders**
  - Variable raw file formats are handled using custom loading scripts
- **Raw Data**
  - Data is fed through a specified loader and inserted into the database
- **Data Management Algorithms**
  - Pass normalized data through three steps, and pass results and filtered point data back to database for storage
  - Anonymyzed version of the data is then sent to the web database for reporting

Approach – Data Selection and Collection

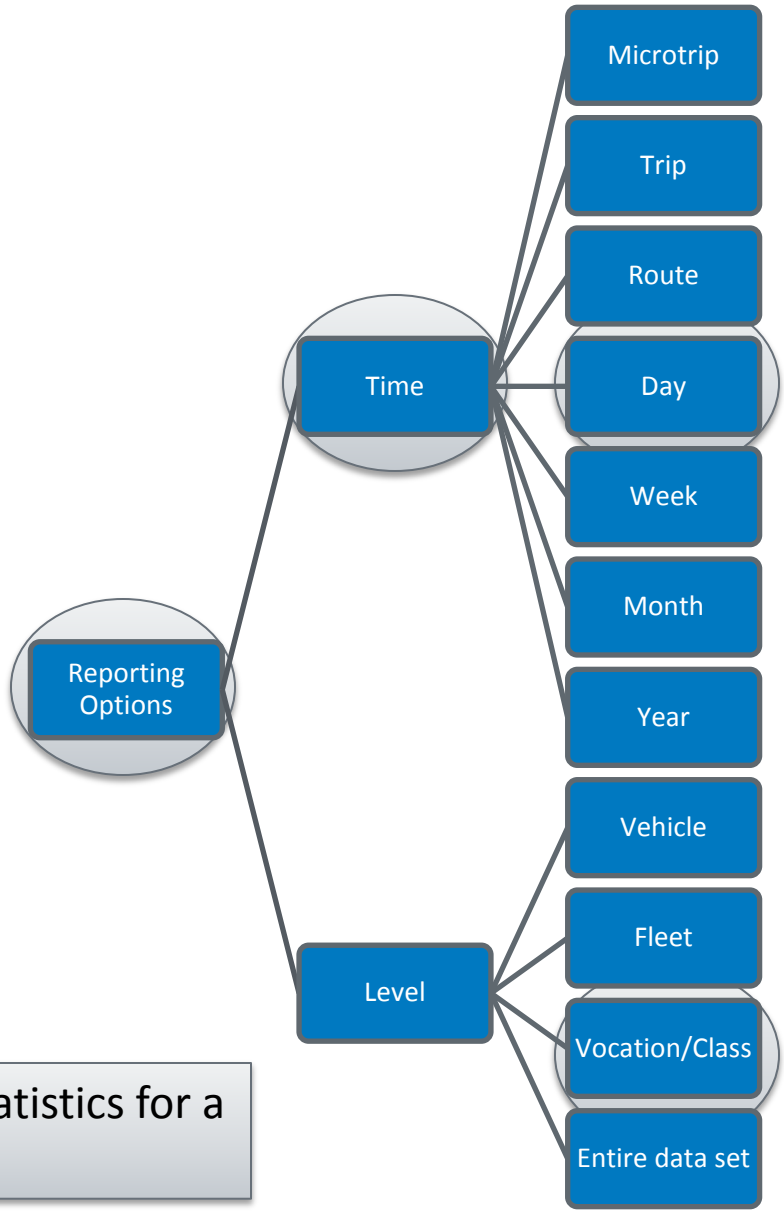
- GPS and Controller Area Network (CAN) data collection
- Data collected via onboard logging either instrumented by researchers or supplied by partners
- Fleet DNA leverages existing DOE VTP data collection efforts, using existing data collection projects as an initial source of database data.
- 10-12 high fuel use vocations initially targeted

- Class 8 OTR Tractor Trailers
- Transit Buses
- Shuttle Buses
  Airport, specialty
- Refuse Trucks
  Multiple types
- Tow Trucks

- Class 4-6 Delivery Vans
  Parcel, food, uniform
- Class 3-4 Light Aerials
  Telecom service
- Class 5-6 Aerial
  Utilities
- Class 3 Service Vans
  Telecom
- Class 8 Tractor Trailers
  Beverage delivery
- Class 6 Box Trucks
  In-city delivery
- EV MD Delivery Vans
  Multiple uses

Approach – Data Reporting

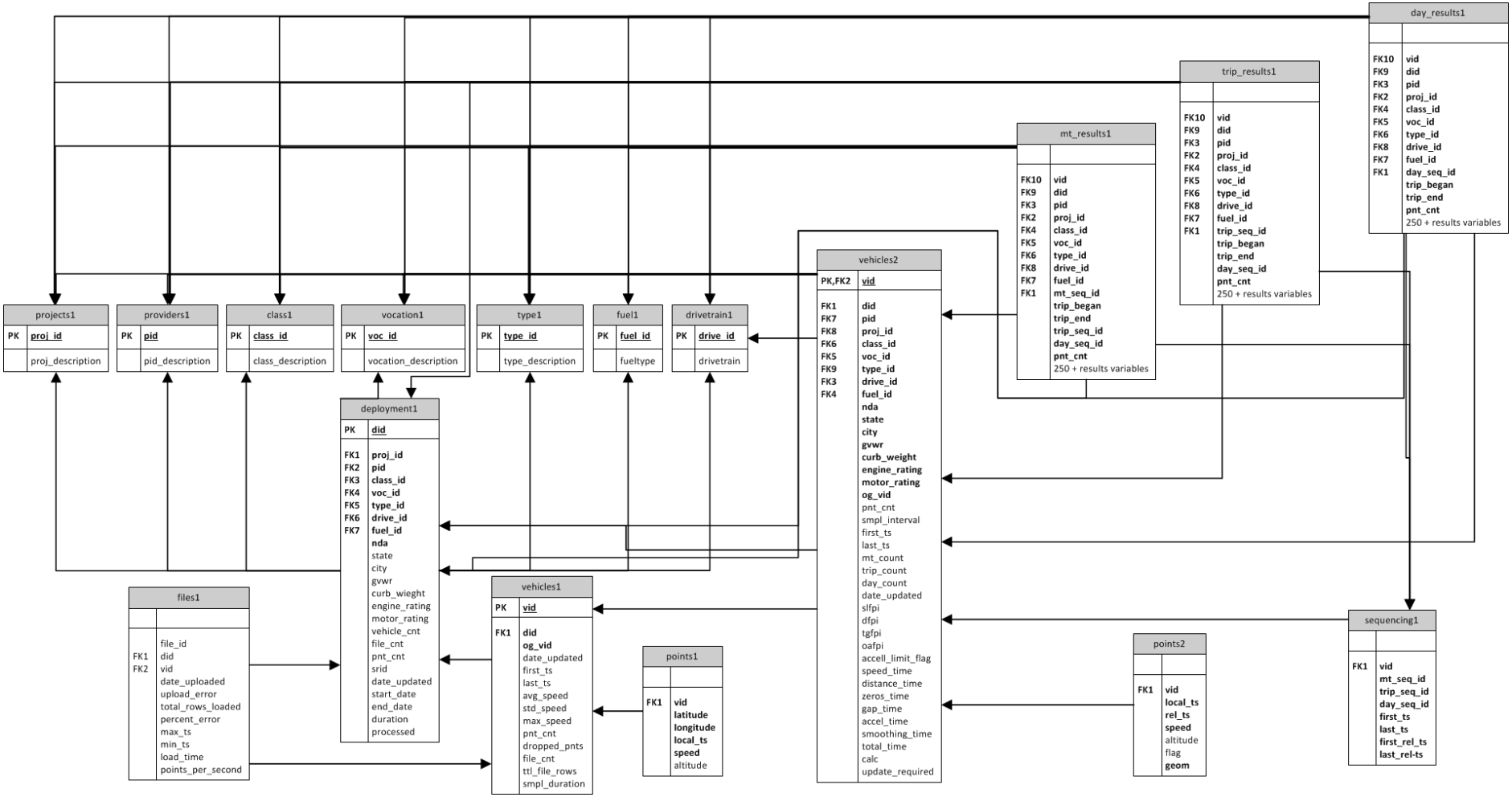
- **Statistics analyzed on multiple levels and application scales**
  - Analyze data on time scales ranging from individual Microtrips to multiple years, attempt to answer questions such as:
    - How does driving behavior change seasonally? Weekly? Daily?
    - How does route A compare to the rest?
    - Why does fuel consumption rise on a Tuesday vs. Thursday?
    - What time of day are vehicles traveling fastest? Covering the most miles?
  - Separate data by individual vehicle, fleet, or vocation/class allowing for additional questions to be answered:
    - Do all vehicles within the fleet operate similarly?
    - What about a specific vocation/class?
    - How do fleets compare across similar applications or geographies?



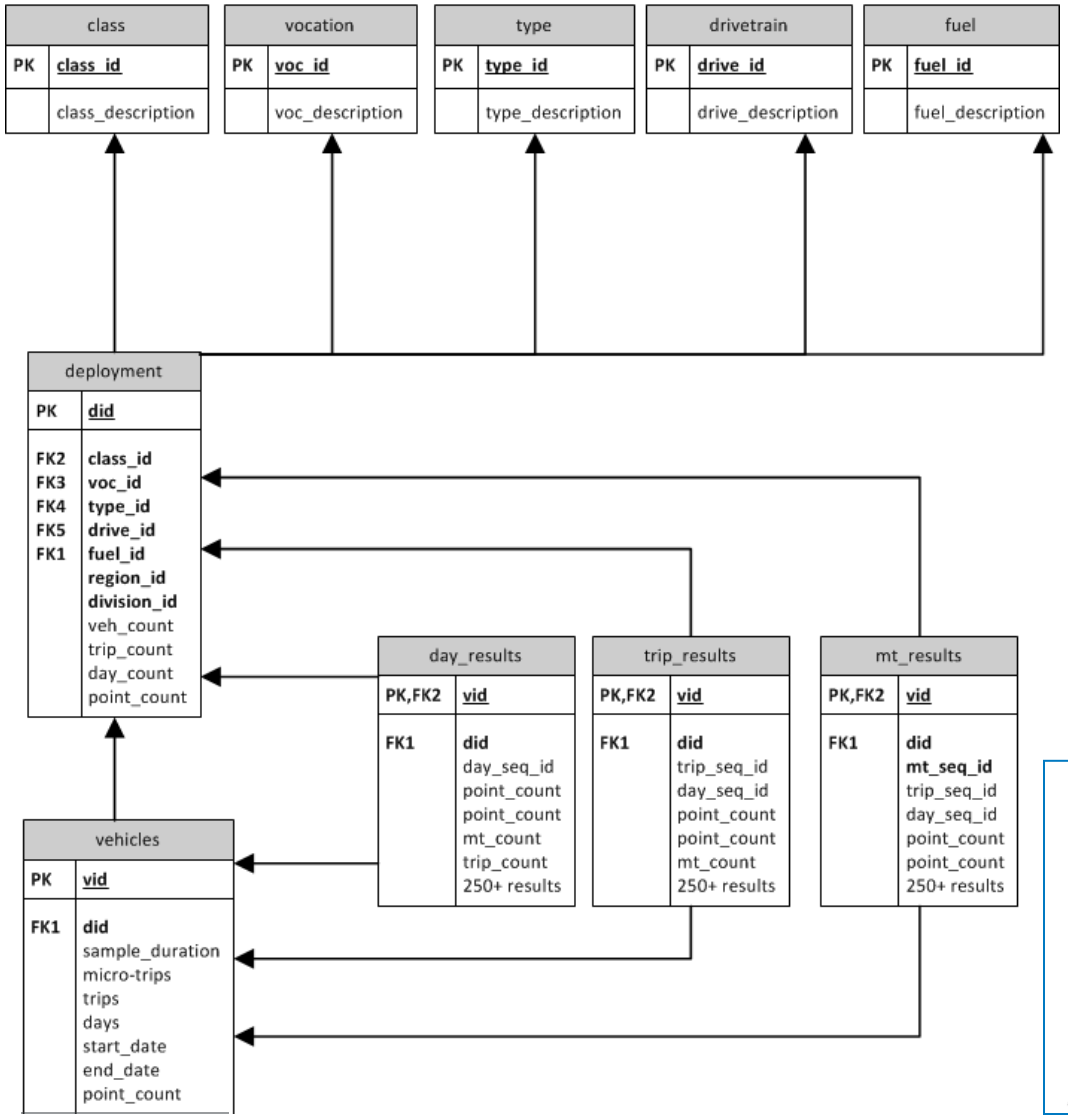
*Example – Reporting daily vehicle operating statistics for a specific vehicle vocation or weight classification

Technical Accomplishments - Master Database

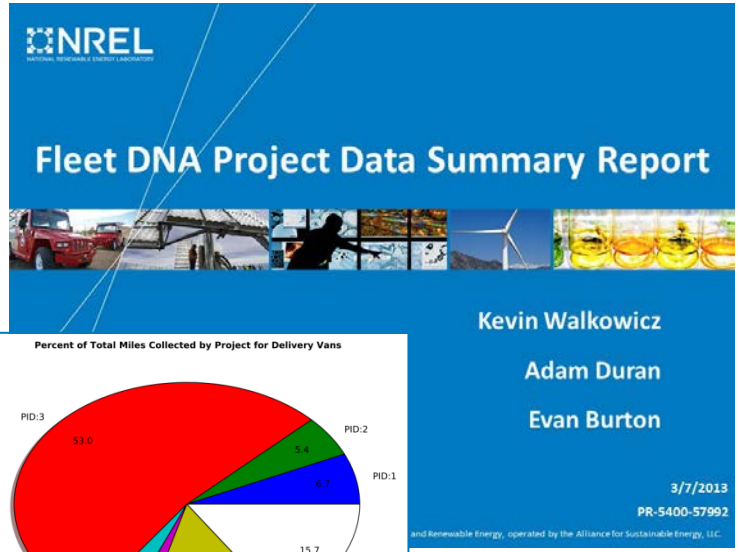
- **Data structure developed to house vehicle operating statistics and operating information for unlimited number of vehicles**
  - *2 organizational levels, one for raw data and one for processed data*



Technical Accomplishments - Web Database

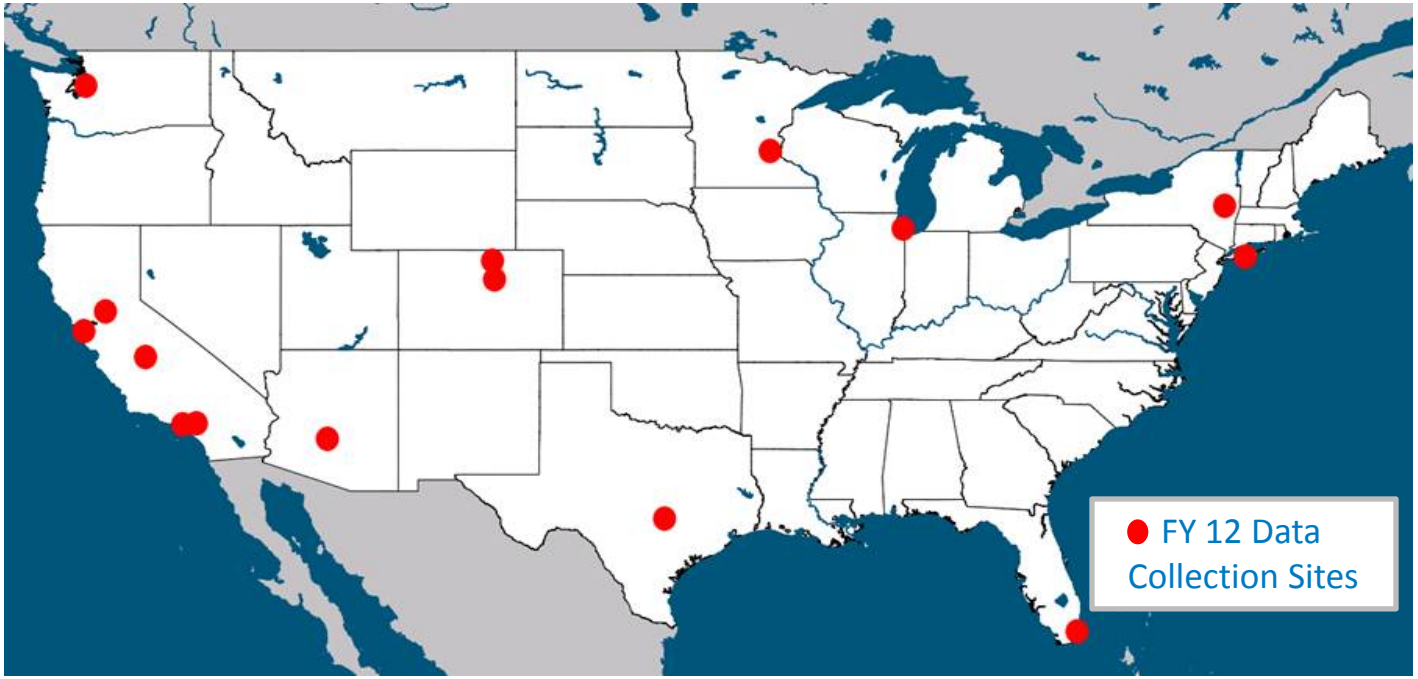


- **Simplified version of the master database developed for public report generation**
- ***No identifying Information***



Technical Accomplishments - Data Collection

Through FY12: 344 vehicles, 16,903 operating hours logged, 101,794 miles collected, and 15 unique geographic locations

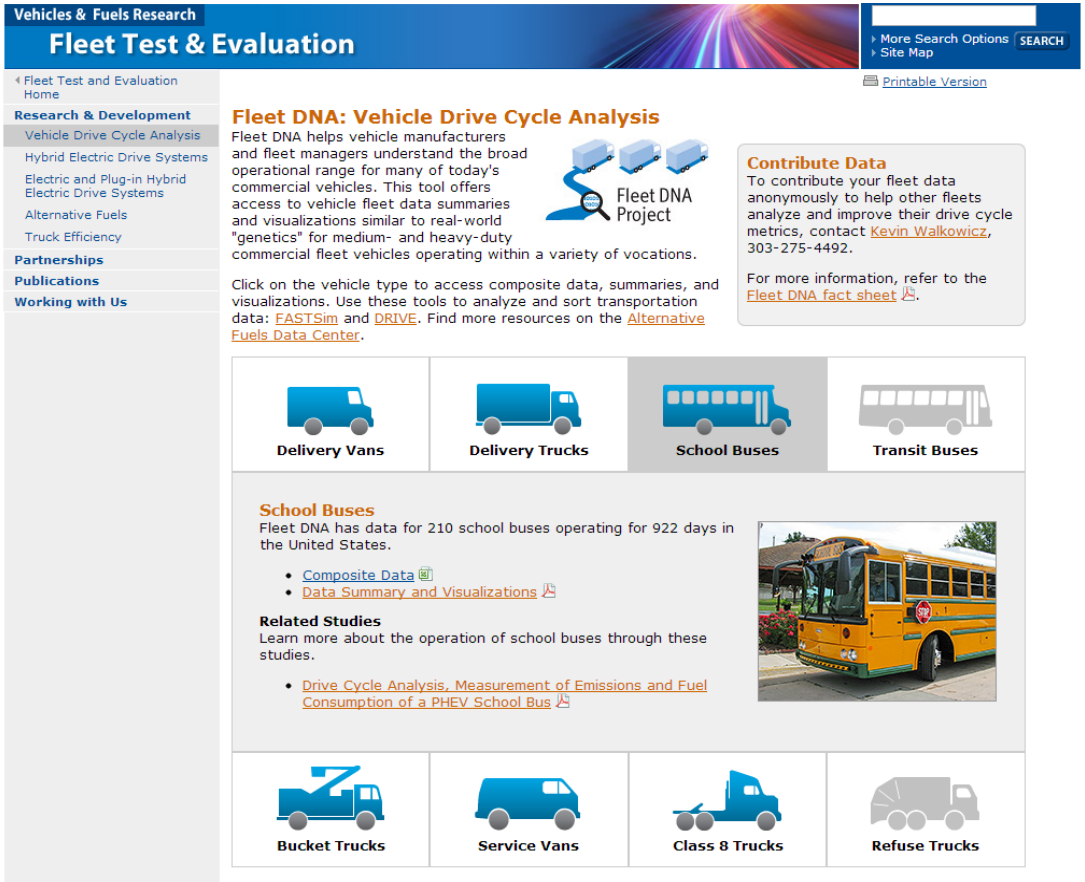


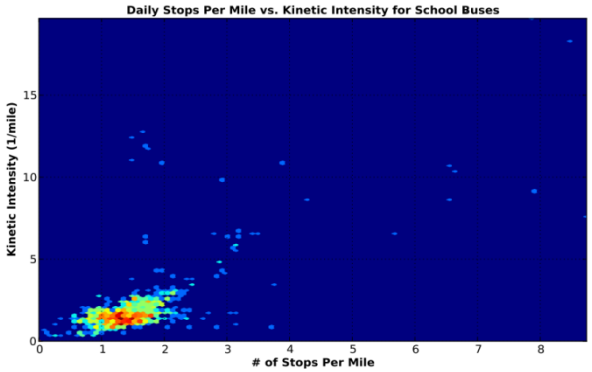
Through FY13: 1000+ vehicles, 50,000+ operating hours logged, 500,000+ miles collected, and 100+ unique geographic locations

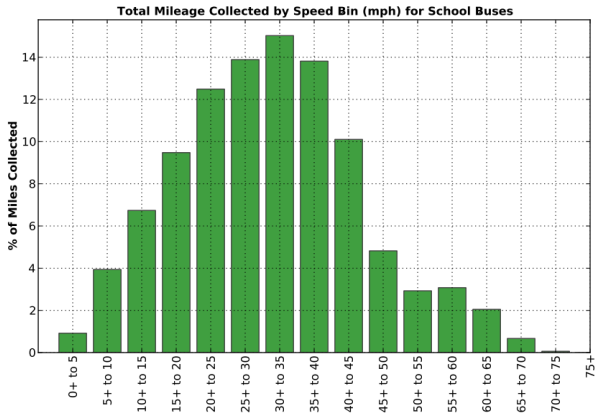
- Dramatic Growth through FY13 as number of project partners expands
  - More data = greater understanding of operating behavior and more potential to uncover previously unobserved trends

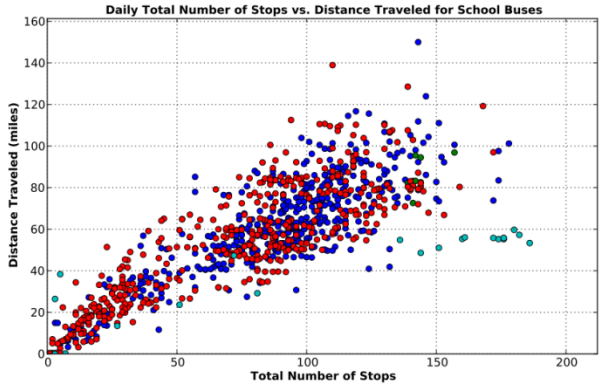
Technical Accomplishments – Data Reporting

- Successful development of vocation specific reports for major vocations of interest
  - 34 unique data products per report
- Fleet DNA website for public data report dissemination: www.nrel.gov/fleetdna



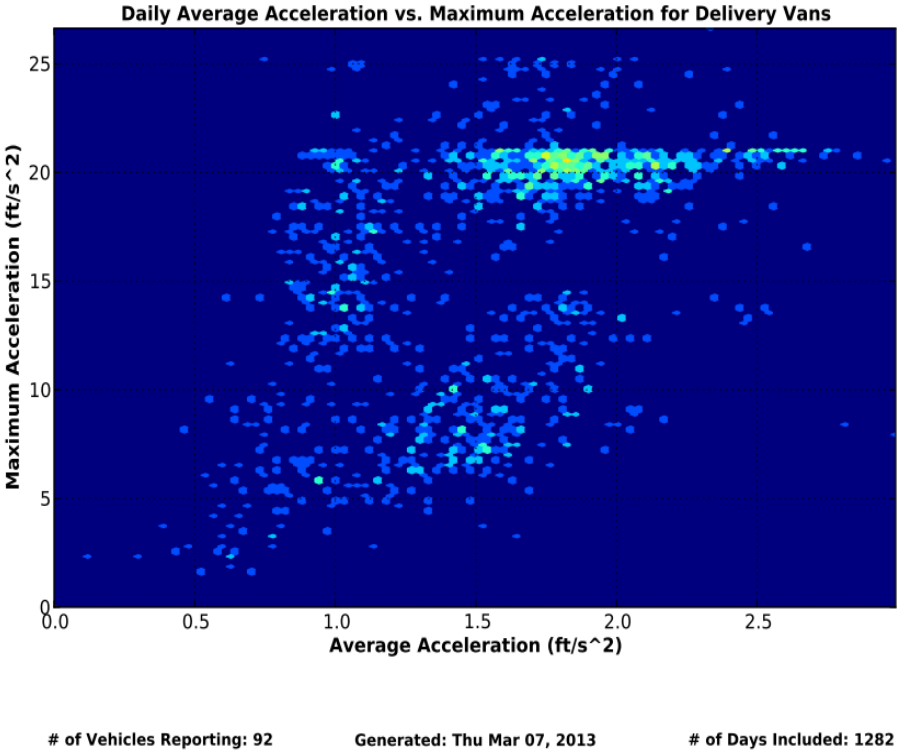


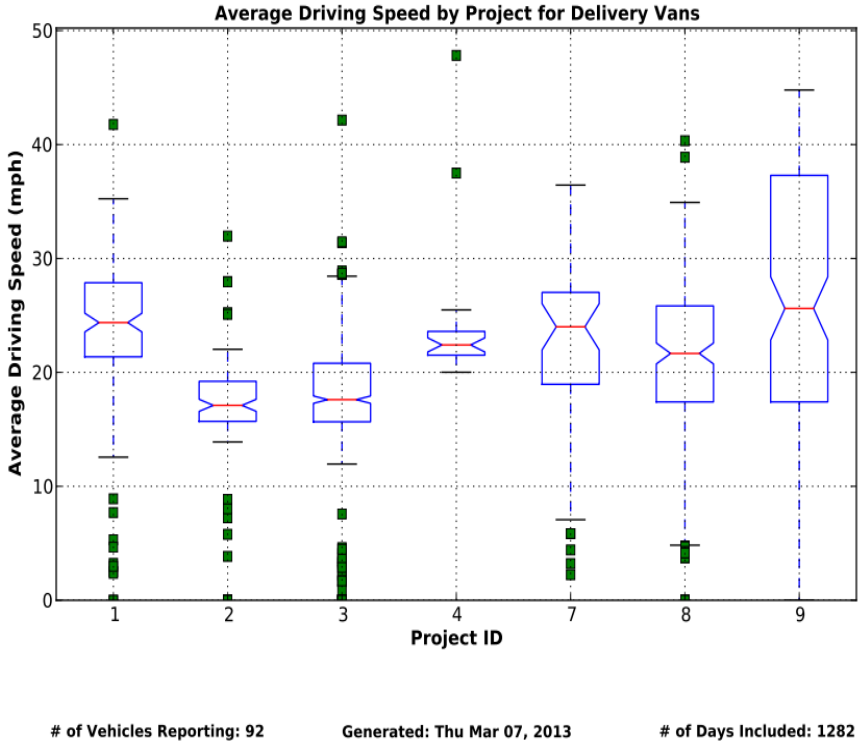




Technical Accomplishments – Data Reporting

- Data products help visualize vehicle use patterns and identify underlying trends
- Graphics such as histograms and scatterplots illustrate data variability
- Reports educate audience and enable calculated decision making, better testing, and improved model integration





Collaboration and Coordination with Other Institutions

Oak Ridge National Lab (ORNL):

- Data collection partner working within the VT program

Preliminary FY12 partners include Calstart, SCAQMD, CARB, Zonar, NTEA/GTA:

- Industry/government/OEM data provider partners
- Support is in-kind (vehicle loans, technical support, data access and data supplied to NREL) and varies by individual partner

Additional data providers planned for FY13:

- With initial database developed and in place as of FY12, future work will be to expand partner network with goal of increasing data provided and range of vocations collected

Proposed Future Work

FY13 Current work is focused on three primary areas:

- **Expansion of data partner network via recruitment**
  - Continue to build out data provider capabilities to enhance Fleet DNA data range and depth
- **Addition of expanded J1939/CAN channel analysis**
  - Potential areas for expansion included powertrain and emissions specific calculations
- **Enhanced data reporting capabilities**
  - Additional data product development and expanded statistical analyses

Looking to FY14 and beyond:

- Integration of Fleet DNA with VTP modeling software for accelerated sweep studies and model validation
- Integration of custom drive cycle generation capabilities for accelerated chassis dynamometer testing activities and modeling
- Development of enhanced database user interface which will allow for dynamic analysis rather than static data product reporting
  - Data sandbox for enhanced education and exploration

Summary

- **Fleet DNA serves as a data storage warehouse for medium and heavy duty vehicle fleets**
  - Demonstration that vehicle drive cycle data can be collected and stored for large scale analysis and modeling applications
    - Data serves as a real world data source for model development and validation
    - Storage of the results of past/present/future data collection efforts improves analysis efficiency through pooling of shared of data and provides opportunity for “big data” type analyses
- **Fleet DNA shows it is possible to develop a common database structure which can store/analyze/report on data sourced from multiple parties, each with unique data formats/types**
  - Data filtration and normalization algorithms developed for the project allow for a wide range of data types and inputs, expanding the project potential
- **Fleet DNA demonstrates the power of large scale analysis and the enhanced understanding and education possible when these capabilities are in place**
  - Need to be able to analyze, store, and visualize/communicate large data sets

Acknowledgements and Contacts

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